Fusion 1: P1.1 – Electricity and Magnetism

National Curriculum Link up
• 2.1a, b. 2.2 b. 2.3a. 3.1b.

Electronic resources: Learning objectives, Practical worksheets, Homework - Batteries, Interactive Drag and drop connector – Battery uses, Video – How much electricity do we use?

Learning Objectives
Pupils should learn:
How to make detailed observations about the operation of circuits.
How to carry out simple experiments safely in a laboratory.
That electrical circuits can be used for a wide variety of functions.

Teaching / Learning activities
Lesson structure
Starter - One hundred years
Use an archive video clip to show the pupils what life was like at the beginning of the 20th century. They can discuss how technology, especially electrical devices, has changed lives in the intervening years. (10–15 mins)
Main
Discuss the function of the circuits with groups of pupils as they test them, so that you can get an impression of their level of understanding. If possible, encourage description of the energy transfers occurring in each of the devices.
The pupils should record their observations clearly. Higher attaining pupils should be giving explanations of what they think is happening in the circuit. Check the notes that the pupils make.
The pupils should gain an understanding that circuits have many uses and that electricity is a very convenient way of transferring energy from place to place.
Plenary - Another hundred years
The pupils should imagine that they are 11-year-olds taking part in a lesson in the year 2100 and describe how different their lives are from those of the pupils today. (10–15 mins)

Teaching suggestions
• **Learning styles.**
Visual: Making observations about circuits.
Auditory: Explaining verbally what is happening in a circuit.
Kinaesthetic: Manipulating a range of circuits.
Interpersonal: Working in groups to discuss the functions of circuits.
• **Functional skills link-up – English**
Present information/ideas concisely, logically and persuasively. (Level 2)
ICT
Organise information of different forms or from different sources to achieve a purpose. (Level 2)

Learning Outcomes
All pupils should be able to list a range of battery-operated devices and discuss their usefulness.
Most pupils should be able to describe what happens when switches are used in particular circuits.
Some pupils should also be able to draw a circuit diagram for a circuit they have investigated.
How Science Works
Identify and use the conventions of various genres for different audiences and purposes in scientific writing. (1.1c)

Additional teachers notes
Equipment and materials required
a) A simple series circuit with a 3 V battery, 'press to make' switch and 3 V lamp. b) A series circuit with a 3 V battery, 3 V lamp and 0–100 kΩ variable resistor that can be used to dim the light. c) A parallel circuit including a 3 V battery and two 3 V lamps controlled by separate switches. d) A low voltage power supply operated electromagnet (nail with coil) and some magnetic pins. Use a 'push to make' switch in the circuit so that it only remains active when the switch is pressed down. e) A parallel circuit with two 3 V lamps powered by a 3 V battery pack. Use a two-way switch on one lamp or the other. f) A battery-powered circuit with a lamp and light dependent resistor. The lamp turns on when the LDR is covered up by the pupils.
Safety
The circuits should be safe to operate, but test the electromagnet to make sure it does not overheat when in operation. Lock the power supply voltage if possible, so that overheating is less likely.

Fusion 1: P1.2 – Complete Circuits

National Curriculum Link up
• 3.1c.

Electronic resources: Learning objectives, Practical worksheets, PowerPoint – Electrical symbols and complete circuits, Interactive Drag and drop – Labelling the symbols on a circuit, Simulation – Torch circuit, Interactive – Using current

Learning Objectives
Pupils should learn:
That a complete circuit is required for an electrical current.
How a circuit can be represented by circuit symbols.
That some materials are good electrical conductors while others are insulators.

Teaching / Learning activities
Lesson structure
Starter - Symbolic
Show the pupils some everyday symbols and ask them to explain what they mean, starting with symbols that give strong visual clues about their meaning and move onto the more abstract. Include the symbols for a switch, lamp and battery. (5 mins)
Main
Pupils can try to build circuits using a range of components in the 'Connecting up' activity. The goal is to get them to construct the circuit correctly and then simply describe what it does.
Pupils need to be shown how to build the circuits component by component, the same way that they trace the current. Start with the battery and add one component at a time until the connections go back to the battery again.
Pupils should be familiar with conductors and insulators, but it is worth demonstrating some materials like plastic strips, copper and graphite rods. Pupils could carry out these tests if time permits.
Encourage pupils to draw correct circuit diagrams using a ruler. Don't allow *any* gaps at all, point out that the circuit would be incomplete; using little 'blobs' to show connections is a good idea.
Plenary - Any bright ideas?
Show the pupils a full-size mains bulb. Ask them to describe which parts conduct and which don't. Show them the internal parts of other components too, a motor for example. (10 mins)

Teaching suggestions
• **Special needs.** For lower attaining pupils, you may wish to use photographs of circuits alongside the circuit diagrams so that the pupils can make connections between them. Locktronic type boards can also make the relationship between diagram and circuit construction easier but they are unreliable when rusty or dirty.
• **Extension.** Higher attaining pupils can add a greater range of components in their circuits including an LED. This should be connected in series with a 1 kΩ protective resistor and to a 4.5 V power supply. Ask them to describe what happens when this is placed facing one direction compared to another. They could also try to build a circuit that can turn a light on and off from two separate switches, like those on landings controlled from upstairs and downstairs.
• **Learning styles.**
Visual: Analysing circuit diagrams and their relationship to physical circuits.
Auditory: Explaining verbally what is happening in a circuit.
Kinaesthetic: Building and manipulating circuits.
Interpersonal: Working in groups to discuss the function of circuits.
Intrapersonal: Thinking back to their KS2 work on electricity.

Learning Outcomes
All pupils should be able to identify the circuit symbols for a battery, bulb and switch.
Most pupils should be able to construct simple circuits from circuit diagrams.
Some pupils should also be able to draw accurate circuit diagrams and explain how they work in terms of current.
How Science Works
Describe and record observations and evidence systematically. (1.2d)

Additional teachers notes
Equipment and materials required
Per group: a battery pack (3 V), two 3 V bulbs, two switches (press to close), six connecting leads, a buzzer, a small electric motor (optional).
Details
The pupils should construct the circuits one at a time and then describe what they do. These descriptions should include what happens when individual switches are pressed. Try to get the pupils to connect the idea of current and energy being provided to components and then being transferred in the components.

Fusion 1: P1.3 – Electric Current

National Curriculum Link up
• 3.1c.

Electronic resources: Learning objectives, Practical worksheets, Animation – Central Heating and circuits, Video – Using an ammeter, Homework – Current flow through circuits

Learning Objectives
Pupils should learn:
That an electric current is a flow of electrons in metal wires.
How to measure the current in a circuit with an ammeter.
How adding components, such as bulbs, affects the current in a circuit.

Teaching / Learning activities
Lesson structure
Starter - A river runs through it
Show the pupils a video clip about the flow of a river from its source into the oceans and perhaps the rest of the water cycle. Concentrate on the flow of the water particles and the word 'current'. (10–15 mins)
Main
Pupils should complete the experiment 'Controlling Current' as describes in the pupil book. They should see how the brightness of the lamp is related to the current, but check that they can state this relationship to you.
The model used in the pupil book is a water flume, where the water represents the electrons and a pump represents the battery. Take great care that the pupils understand that you are attempting to describe what the current is like, not what it actually is. The water current does not get used up as it goes around the flume and similarly the electrons in the circuit are not used up when they travel. This is a point very often misunderstood by pupils with a majority believing that electrons are used up when they light up the lamp. Some pupils may point out that some water escapes. This is a limitation with the model and you may wish to explain that all science models have some limits.
Plenary - Electron journeys
Ask the pupils to imagine they are an electron on a journey around a circuit that has a cell, two bulbs and a variable resistor. Ask them to describe this journey using the key words: current, energy, cell, bulb, heat and light. Some pupils may like to do this as a comic strip. (10–15 mins)

Teaching suggestions
• **Special needs.** Pupils may need some help setting up the circuits. As in the previous lesson the pupils could be given photographs of what the completed circuit should look like. Locktronic type boards are also an option.
• **Extension.** With higher attaining pupils you should discuss energy in the circuit and log flume in more detail. [The battery provides the electrons with energy and they lose this energy as they travel around the circuit. In the log flume the pump lifts up water and provides it with energy that is consequently loses as it travels back around the loop.] You could ask the pupils to try to come up with their own model to describe an electric circuit. This is rather a difficult task, but they could be lead towards a rollercoaster type model or even a central heating version.
• **Learning styles**
Visual: Analysing circuit diagrams and their relationship to physical circuits.
Auditory: Explaining verbally what is happening in a circuit.
Kinaesthetic: Building and manipulating circuits.
Interpersonal: Working in groups to build circuits.
Intrapersonal: Appreciating that electrons are not used up when they travel around a circuit.
• **Homework.** The 'electron journeys' plenary makes a good homework task. The pupils can read out some of their descriptions next lesson and you can make sure that they use the correct concepts.

Learning Outcomes
All pupils should be able to measure an electric current using an ammeter.
Most pupils should be able to describe how an electric current can be increased.
Some pupils should also be able to describe an electric current in terms of electron movement.
How Science Works
Use an existing model or analogy to explain a phenomenon. (1.1a1)

Additional teachers notes
Equipment and materials required
Per group: a 12 V power supply, a 10 W bulb (or three), a variable resistor (1 kΩ), an ammeter, four connecting leads.
Details
Sometimes the ammeter is connected the wrong way around and gives a negative value; this confuses some pupils so get them to switch the leads to the meter around.

Fusion 1: P1.4 – Cells and Batteries

National Curriculum Link up
• 3.1c.

Electronic resources: Learning objectives, Practical worksheets, Homework – Battery recycling and recharging

Learning Objectives
Pupils should learn:
That cells/batteries produce a voltage that causes an electric current in a complete circuit.
The size of a voltage depends on the number, and orientation, of the cells.
How to use a voltmeter to measure the voltage in a circuit.

Teaching / Learning activities
Lesson structure
Starter - Potato clock
Show the pupils a clock that operates using potato power. These are available in various gadget shops. Ask them to explain how they think it works. (10–15 mins)
Main
'Botanical batteries' can take up a quite a bit of time but is well worth carrying out. With the higher attaining pupils you may wish to introduce the use of a voltmeter to measure voltage produced by the fruits. The results from the battery experiment can be varied, so get the groups to compare results with each other until they reach an appropriate conclusion about which fruit provides the highest voltage (usually kiwi). Talk about the fairness of comparing results across groups.
After the practical is complete, you can show the pupils the inside of a simple battery to show that these depend on a chemical reaction to provide their voltage too.
Discuss the energy transfer taking place inside the cell; chemical energy is transferred to electrical energy (and thermal energy warming up the cell). A battery 'dies' when all of the chemicals have reacted together.
Plenary - Do not dispose of in fire
Batteries should not be disposed on in general household waste. Take the opportunity to discuss the environmental impact of battery disposal. The pupils should design a battery disposal point for the UK to be situated in a supermarket. They could also produce a leaflet to encourage people to dispose of batteries properly. (10–15 mins)

Teaching suggestions
• **Special needs.** Lower attaining pupils will need quite a bit of support in building their circuits. You may want to limit each group to one type of fruit, and then they can investigate the effect of increasing the number of fruits without changing the type of fruit. The results can then be shared with other groups.
• **Extension.** Challenge higher attaining pupils to design a device that operates on 'fruit power'. They can even work on a marketing campaign for their product. Remember, fruit is renewable.
• **Learning styles**
Visual: Designing an advertising campaign.
Auditory: Discussing the uses and limitations of batteries.
Kinaesthetic: Testing different fruits in a practical task.
Interpersonal: Working in groups during experiments.
Intrapersonal: Making conclusions about which fruit would make the best battery.
• **Homework.** The pupils could make a plan to test the claims about how long a rechargeable battery in a portable music player actually lasts. Can they really play music for 24 hours before needing to be recharged?

Learning Outcomes
All pupils should be able to describe what happens to the voltage of cells when they are combined in a battery.
Most pupils should be able to describe what happens to the current in a circuit when the voltage is increased.
Some pupils will also be able to measure the voltage of a battery using a voltmeter.
How Science Works
Recognise the range of variables involved in an investigation and decide which to control. (1.2b)

Additional teachers notes
Equipment and materials required
Per group: a range of citrus fruits (lemon, orange, kiwi, grapefruit) quartered, a 1.5 V bulb, a voltmeter and or milli-ammeter, a copper and a zinc electrode (just strips of the metal that won't bend too much), connecting leads, crocodile clips, a tray.

Fusion 1: P1.5 – Shocking Stuff

National Curriculum Link up
• 3.1c.

Electronic resources: Learning objectives, Practical worksheets, Plenary activity – Shocking stuff, Interactive Drag and drop – Electrical safety, Video – Blowing a fuse, Simulation – Building a circuit with resistance

Learning Objectives
Pupils should learn:
That mains electricity is at a high voltage and that it can force a current through a person.
That the current can cause burns or even kill.
That a fuse is a device designed to melt if the current is too large.

Teaching / Learning activities
Lesson structure
Starter - Hot stuff
Ask the pupils to list as many devices that use electricity to produce heat as they can. Then they should list all of the other electrical devices that produce heat as a side effect [almost everything]. (5–10 mins)
Main
Due to the danger of mains electricity, there are a number of demonstrations in this lesson instead of a major practical activity for the pupils. The pupils should leave the lesson understanding the dangers of using mains electricity inappropriately, but they should not be afraid of its safe use.
You should demonstrate:

- Electrical conduction through water
- A fuse blowing
- Allow low voltage lamps to heat up

Bathrooms needs to have electric lights and sockets for electric razors. Discuss how these are made safe in the bathroom [pull cords, extra earthing]. At the end of the lesson, remind the pupils that mains electricity is perfectly safe as long as it is used correctly.
Plenary - Clear!
Show a video clip of a patient being shocked to restart the heart. The doctor always shouts 'Clear!' Ask the pupils to explain why this is important. What would happen to anybody touching the patient? What could happen to any electronic equipment? (5–10 mins)

Teaching suggestions
• **Special needs.** For these pupils concentrate on the safety features used to protect users from mains electricity.
• **Extension.** These pupils should take a look at mains electricity in other countries. They can find out about the supply in the USA. They could take a look at what alternating current is compared to direct current and find out about the mains frequencies used in the UK and USA.
As an alternative, the pupils can look at the connection between resistance and the heating effect of a current. You can go through the model of electrons colliding with ions in the metal to release energy.
• **Learning styles**
Visual: Watching various demonstrations.
Auditory: Listening to, and giving, explanations about why mains electricity is dangerous.
Interpersonal: Discussing the dangers of mains electricity in groups.
• **Homework.** The pupils can produce an electrical safety booklet containing a list of what we should and shouldn't do with mains electricity.

Learning Outcomes
All pupils should be able to describe the action of a fuse.
Most pupils should be able to explain why mains electricity is dangerous.
Some pupils will also be able to state the UK mains voltage and to link this with the level of danger.
How Science Works
Explain how action has been taken to control obvious risk and how methods are adequate for the task. (1.2c)

Additional teachers notes
Equipment and materials required
A 9 V battery (or low voltage d.c. power supply), a 500 cm3 beaker, distilled water, salt, a stirrer, a 3 V lamp, connecting leads.
Details
Set up a series circuit with the lamp and battery so that there is a gap between two leads. Place the two leads in a beaker of distilled water and the lamp will not light. Make sure that the pupils understand that you are using a low voltage and you would never try this with mains electricity. Gradually stir salt into the water and the lamp will light as the current passes through the solution.

Fusion 1: P1.6 – Series and Parallel

National Curriculum Link up
• 3.1c.

Electronic resources: Learning objectives, Practical worksheets, Plenary activity – Series and parallel, Additional support - Missing measurements, Interactive Drag and drop connector – Key terms and symbols, Interactive – Producing heat energy

Learning Objectives
Pupils should learn:
That in a series circuit the current is the same through all devices.
How the current divides in parallel circuits.
That the voltage across parallel branches is the same.

Teaching / Learning activities
Lesson structure
Starter - Continuity checking
Check that the pupils have remembered the key words and ideas from the previous lessons by using a crossword. (10 mins)
Main
Start by making sure that the pupils understand the meaning of the word 'series' as in 'one after another'. Pupils can then carry out the 'Measuring current' activity.
After the practical you can show the circuit with three separate ammeters in it to confirm that the current is the same at the three different points.
Remind the pupils of the meaning of the word 'parallel'. They need to get the idea that the components are alongside each other and current can go both (or more) ways. Pupils can now do the 'Switches in control' activity; they should attempt to measure the voltages across components in parallel.
Measuring the voltage across components in parallel circuits will be particularly difficult for some. Make sure you demonstrate how to connect and move the voltmeter before the pupils start on the task. Check that all of the pupils have the expected results from the practical.
To sum up the key ideas of the lesson a computer model/animation should be used to look at what is happening to the current in the circuit.
Plenary - Connect-up cards
Give the pupils a set of cards containing circuit symbols. The pupils have to place the cards in a way that makes a functioning circuit where all of the readings are correct. (5–10 mins)

Teaching suggestions
• **Special needs.** Lower attaining pupils will need a lot of support, especially in measuring voltages. If the pupils struggle, then just get them to measure voltages in a series circuit and note that the voltage is 'shared'.
• **Extension.** These pupils can attempt to make measurements in more complex circuits. Ask the pupils to build a circuit that has two lamps in parallel followed by one in series and to investigate the current through and voltages across the bulbs. Pupils could use their knowledge of circuits to design a circuit for stairs lights that can be switched on and off by two separate switches (one upstairs and one downstairs).
• **Learning styles.**
Visual: Picturing electron movement.
Auditory: Describing the flow of current in various circuits.
Kinaesthetic: Constructing circuits.
Interpersonal: Working in groups to set up circuits.
Intrapersonal: Making deductions about the behaviour of current in parallel circuits.
• **Homework.** Give the pupils a worksheet showing circuit diagrams with missing measurements. The pupils must use their knowledge of series and parallel circuits to fill in the gaps using the information already present.

Learning Outcomes
All pupils will be able to describe the behaviour of the current in a series circuit.
Most pupils will be able to describe how the current divides in a parallel circuit.
Some pupils will also be able to state that the voltage across parallel branches in a circuit is the same.
How Science Works
Describe and record observations and evidence systematically. (1.2d)

Additional teachers notes
Measuring current
Equipment and materials required
Per group: battery packs or low voltage power supply, two 3 V lamps, ammeter, connecting leads.
Switches in control
Equipment and materials required
Per group: battery packs or low voltage power supply, two 3 V lamps, two switches, ammeter, connecting leads.

Fusion 1: P1.7 – Magnetic forces

National Curriculum Link up
• 3.1b.

Electronic resources: Learning objectives, Practical worksheets, Homework – Magnetism in the home, Interactive – Magnetic fields and magnetism

Learning Objectives
Pupils should learn:
That some materials are magnetic while others are not.
That magnets have two poles named 'north' and 'south'.
About the interactions and forces between north and south poles of a magnet.

Teaching / Learning activities
Lesson structure
Starter - Force facts
Get the pupils to list as many facts about forces and their effects as they remember. (5–10 mins)
Main
Start by demonstrating the effect of a magnet on a magnetic material and the lack of effect on a non-magnetic one.
Pupils may already be aware of the idea of poles and they will know that these are found at the ends of the bar. You could show a horseshoe magnet to show that the position of the poles can be different.
The 'opposites attract' idea will be commonly known, but some pupils will be confused by the term 'like' so use alternative phrases as well such as 'same poles'.
The pupils should spend a major portion of the lesson handling magnets, especially during the game construction. You should have some designs in mind or even complete designs to support lower attaining pupils.
Plenary - Attract or repel?
Show the pupils a range of diagrams of various combinations of magnets. Ask them to describe what would happen to these. (5 mins)

Teaching suggestions
• **Special needs** You may want to mark the poles of magnets with N and S in permanent marker (or white paint for black magnets), especially if you use unusual magnets. Provide designs for the games for lower attaining pupils so that they can spend more time constructing and playing them.
• **Extension.** These pupils should investigate magnets other than bar magnets to find the poles. Possibilities include horseshoe magnets and magnets where the poles are on the larger faces, such as the ferrite magnets often used in building model motors. They could also research into which materials can be used to make permanent magnets.
• **Learning styles**
Auditory: Discussing game design.
Kinaesthetic: Experimenting with magnets and constructing magnetic games.
Interpersonal: Discussing the design of magnet-based games.
Intrapersonal: Collaborating with others during game construction.
• **Homework.** The pupils could make of list of all of the devices they can find that use magnets in their home.

Learning Outcomes
All pupils will be able to describe a simple test for magnetic materials.
Most pupils will be able to describe the interactions between combinations of magnetic poles.
Some pupils will also be able to describe that when a magnetic material is placed near a magnet it also becomes a magnet.
How Science Works
Describe an appropriate approach to answer a scientific question using a limited range of information … (1.2a)

Additional teachers notes
Pole position
Equipment and materials required
Per pupil: a pair of bar magnets and a steel paper clip.
Pole puzzle
Equipment and materials required
Per group: three bar magnets, some card. The exact requirements for the games depend on the designs the pupils come up with, but you should provide them with a range of magnets in different sizes, cardboards, scissors, pens and plastic Petri dishes as starting points.
Details
Pupils can design and build a simple game based around magnetic material.
Safety
If iron filings are used then the pupils will need to wear eye protection. They should also wash their hands afterwards to remove any stray particles.

Fusion 1: P1.8 – Making Magnets

National Curriculum Link up
• 3.1c.

Electronic resources: Learning objectives, Practical worksheets

Learning Objectives
Pupils should learn:
How permanent magnets can be made using strong magnets.
About methods for testing the strength of a magnet.

Teaching / Learning activities
Lesson structure
Starter - MAGNET acrostic
Can the pupils come up with an acrostic using the word 'magnet' that is related to how they work? (5–10 mins)
Main
Start the lesson by demonstrating how to make a magnet using a large steel nail as described in the pupil book. After making the magnet, you can try to demonstrate that it will lose some of its magnetic strength if it is banged. Whack it against a solid object a few times and it *should* get weaker. Use this idea to show the pupils it is important to handle their magnets with care or they will get weaker too.
The pupils should now try one of the 'testing magnets' activities. You may want to assign the methods to different groups of pupils or let them decide for themselves. Try to make sure that all of the methods are used by pupils so that they can all be evaluated.
Plenary - Correct me if I'm wrong
Give the pupils a paragraph with many mistakes explaining how to test a magnet's strength. They have to correct the mistakes. (5–10 mins)

Teaching suggestions
• **Special needs.** Provide the pupils with more detail about the techniques used to compare magnets. A set of step-by-step instructions would be appropriate.
• **Extension.** Ask the pupils to design and carry out an experiment to find out if a material placed between two magnets can affect the strength of the field.
• **Learning styles**
Visual: Watching the demonstration of how to make a magnet.
Auditory: Describing their ideas about which test is best.
Kinaesthetic: Testing the strength of magnets.
Interpersonal: Working in groups.
Intrapersonal: Discussing the choice of tests and their outcomes.
• **Homework.** They should write a short essay on the discovery of magnetism, the compass and how it led to the exploration of the Earth.
• **Functional skills link-up – ICT**
Access, navigate and search internet sources of information purposefully and effectively. (Level 1) See Homework Suggestion.

Learning Outcomes
All pupils will be able to make a simple permanent magnet.
Most pupils will be able to test the strength of a magnet.
Some pupils will also be also able to evaluate the methods used for testing the strength of a magnet.
How Science Works
Describe an appropriate approach to answer a scientific question using a limited range of information and making relevant observations or measurements. (1.2a)
Describe and suggest how planning and implementation could be improved. (1.2e)

Additional teachers notes
Make your own magnet
Equipment and materials required
A permanent bar magnet, an un-magnetised nail or needle, digital electronic balance and block of iron or steel.
Safety
Needles and nails are sharp. If pupils rub the needle against the magnet they are more likely to stab themselves, so make sure that they move the magnet, not the needle.
Testing magnets
Equipment and materials required
Depending on which tests the pupils choose they will need two bar magnets and one of the following sets: a) paper clips, b) paper clip, cotton, small equal masses (beads are good), c) cardboard, paper clips, d) paper clips, e) a plotting compass or f) a top-pan balance and small iron block.
Safety
Keep strong magnets away from electronic equipment and data storage systems.

Fusion 1: P1.9 – A Field of Force

National Curriculum Link up
• 3.1b.

Electronic resources: Learning objectives, Practical worksheets, Webquest - Magnetism

Learning Objectives
Pupils should learn:
That magnets have a field round them that can be represented in a diagram.
That magnets interact with each other through these fields.

Teaching / Learning activities
Lesson structure
Starter - Is it really there?
The pupils need to make of list of things that they cannot see (e.g. air, gravity). They then need to give explanations of how they could prove that these things exist. (10 mins)
Main
Demonstrate the shape of the field by sprinkling iron filings onto card with a magnet beneath. This makes the concept a bit more real. If you have an overhead projector, place the magnet beneath a transparency, or clear plastic box with lid, and then sprinkle.
The direction of the force lines is important. If pupils ask why they go in that particular direction, and then explain that it is the direction a north pole would be pushed if it were placed there.
The 'It's all a plot' practical is straightforward ways of letting the pupils find the field for themselves. It's a lot less messy than using iron filings. If you do want to let the pupils have a go with the iron filings, then make sure the magnets are covered in cling film; this makes it a lot easier to clean the magnets afterwards.
When discussing the Earth's magnetic field, you should have a globe to make sure the pupils know the locations you are discussing. You can also show them where the bar magnet would have to be to generate the field.
Plenary - Model Earth
The pupils have to design a model for the Earth that includes its magnetic field. They should draw out their design and list the material they would use. (10 mins)

Teaching suggestions
• **Special needs.** For the 'It's all a plot' activity the pupils should use a worksheet with the position for the magnet and various positions for the compass already marked on it.
• **Extension.** The pupils could plot the field of a horseshoe magnet. They could also look in more detail at the Earth's magnetic fields and what it does to protect the planet.
• **Learning styles**
Visual: Drawing and observing magnetic fields.
Auditory: Discussing methods of detecting invisible things.
Kinaesthetic: Plotting magnetic fields.
Intrapersonal: Visualising the structure of the Earth and its field.
• **Homework.** Set the pupils a history lesson task. They must write a short essay on the discovery of magnetism, the compass and how it led to the exploration of the Earth.
• **Functional skills link-up – ICT**
Access, navigate and search internet sources of information purposefully and effectively. (Level 1) See Homework Suggestion.
• **Did you know?** The compass was a Chinese invention, a loadstone floating on water, originally used in practices such as feng shui and fortune telling. It took over a thousand years before sailors realised how useful it would be in working out directions. It is unclear if the compass was independently invented in Europe, but Europeans significantly developed the device into what it is today. Of course, satellite navigation has made the compass all but obsolete for navigation at sea.

Learning Outcomes
All pupils will be aware that magnets, including the Earth, have a field around them.
Most pupils will be able to detect and draw the shape of the field around a bar magnet.
Some pupils will also be able to explain how a compass operates in the Earth's magnetic field.
How Science Works
Describe and record observations and evidence systematically. (1.2d)

Additional teachers notes
Equipment and materials required
A permanent bar magnet, A3 paper, a plotting compass.
Details
The pupils should place the magnet in the centre. They should then draw around it to get a permanent record of where it was and so that they can replace it if they knock it. They should then place the compass at different points around the magnet, working away from one of the poles, and trace the field.

Fusion 1: P1.10 – Electromagnets

National Curriculum Link up
• 3.1b.

Electronic resources: Learning objectives, Practical worksheets, Starter activity - Anagramania, Starter activity - Electromagnets

Learning Objectives
Pupils should learn:
That an electric current produces a magnetic field.
That the strength of the field is increased in a coil.
That increasing the current, the number of loops in the coil and adding a magnetic core can increase the strength of the magnetic field.

Teaching / Learning activities
Lesson structure
Starter - Anagramania
Give the pupils a set of anagrams of words from the electrical circuits and magnets topic so far, and ask them to solve them. (5–10 mins).
Main
Show the pupils an electromagnet made from a coil of wire and contrast with the photograph in the pupil book.
Demonstrate that the field around a solenoid only exists when there is a current. Place a set of plotting compasses around it and turning it on and off.
The pupils should now try to make an electromagnet themselves. It can be quite difficult for pupils to get the coil just right. The pupils should make sure that they think about potential risks associated with the magnets; they should be aware of the heating effect of the electric current.
Discuss the methods of making the magnet stronger, but point out the disadvantages too. The pupils can then test the strength of the electromagnets with the second practical task, 'Testing an electromagnet'.
Plenary - Electromagnetic info
The pupils have to make a summary and comparison of magnets and electromagnets. (10 mins)

Teaching suggestions
• **Special needs.** Have some coils with and without a core already prepared, to make the setting up of the practical tasks easier. The pupils can spend more time making measurements.
• **Extension.** Some very powerful electromagnets are used in medical devices such as PET scanners. These magnets carry high currents and have to be cooled to very low temperatures. The pupils could find out why they have to be cooled and what a superconductor is.
• **Learning styles**
Visual: Designing the shape of an electromagnet.
Auditory: Discussing how an electromagnet can be made stronger.
Kinaesthetic: Practical work.
Interpersonal: Discussing the factors that increase the strength of an electromagnet.
• **Homework.**
'Can Do': the pupils can design a machine that separates out steel cans from the more valuable aluminium ones.

Learning Outcomes
All pupils will be able to describe how an electromagnet is made.
Most pupils will be able to describe how the strength of an electromagnet can be increased and a method of testing this.
Some pupils will also be able to evaluate methods for testing the strength of an electromagnet.
How Science Works
Recognise the range of variables involved in an investigation and decide which to control. (1.2b)

Additional teachers notes
Making an electromagnet
Equipment and materials required
Each group will require: a low voltage d.c. power supply, connecting leads, crocodile clips, a long iron nail, a paper, card or plastic tube (thin is better), paper clips and an insulated length of wire to form the coil. The length of wire required will depend on the size of the tube, but it should be long enough to wrap around the tube 20 times. The same length of wire should be used throughout the experiment to limit the current.
Testing an electromagnet
Equipment and materials required
Each group requires the same equipment as before, ammeter and variable resistor.
Safety – for both experiments
Electromagnets can heat up and cause the circuit breaker in power supplies to trip. Test the circuit before use to make sure that it cannot heat up too much.

Fusion 1: P1.11 – Electromagnets at Work

National Curriculum Link up
• 3.1b.

Electronic resources: Learning objectives, Practical worksheets, Plenary activity – Electromagnets at work, Interactive Drag and drop connector – Magnetism key terms, Homework – Quiz word, Additional Support – Electromagnets in speakers, PowerPoint – How do we use magnets, Animation – DC electric bell

Learning Objectives
Pupils should learn:
That the shape of a magnetic field around the electromagnet is similar to that around a bar magnet.
About the applications of an electromagnet.

Teaching / Learning activities
Lesson structure
Starter - Eye know how
The pupils have to design a device that can remove a metal splinter from the eyeball of a patient. Their designs must be very controllable and easy to operate. A circuit diagram should be included too. (10–15 mins)
Main
Start by showing the shape of the field around a bar magnet again and then comparing this to the field around an electromagnet. The pupils can then check the comparison using 'The field of an electromagnet' practical
The lesson them moves on to the applications of electromagnets, starting with a doorbell. It is important to get across to pupils that without electromagnetic devices, many of the things they take for granted would not operate. Every device that produces movement from electrical power needs an electric motor and these use electromagnets.
The pupils can then investigate other devices, including an electric bell and relay, depending on what is available. See practical 'How it works'.
Plenary - Key points
Test the pupils understanding with a range of verbal questions about magnets and electromagnets. (5 min)

Teaching suggestions
• **Special needs.** Provide descriptions of how electromagnetic devices work but jumble up the order. The pupils have to sort this order out to get the correct description for each device.
• **Extension.** Pupils could look at how a loudspeaker operates in more detail. They need to understand why an electromagnet and a permanent magnet are used in combination.
• **Learning styles**
Visual: Examining electromagnetic devices.
Auditory: Describing how a device operates.
Kinaesthetic: Plotting the field of an electromagnet.
Interpersonal: Discussing the operation of electromagnetic devices.
Intrapersonal: Predicting the effect of changing the current on an electromagnet.
• **Functional skills link-up – English**
Use a range of different styles of writing for different purposes. (Level 2) See Homework Suggestion.
• **Homework.** Electromagnets are common, but can the pupils come up with a new idea for their use? They can produce an advertisement or instruction manual for their devices.

Learning Outcomes
All pupils will be able to list some uses of an electromagnet.
Most pupils will be able to describe the advantages of using electromagnets in comparison to permanent magnets.
Some pupils will also be able to describe the operation of some electromagnetic devices in detail.
How Science Works
Describe and record observations and evidence systematically. (1.2d)

Additional teachers notes
Equipment and materials required
There are three pieces of equipment to investigate. a) An electric bell connected to a power supply with a switch. b) A relay set up so that one circuit turns on another circuit. This will require two power supplies, connecting leads and a bulb. c) A set of headphones connected to a signal generator.
Details
a) The electric bell should be set so that it vibrates but not too loudly. If you can, limit the voltage on the power supply.
b) The relay should be set so that when one circuit is switched on the relay becomes activated and turns on a separate circuit containing a light bulb.
Safety
Make sure that it is not possible for the pupils to connect any of the devices directly to the mains supply.


FUSION